CLAIMS

What is claimed is:

1. A method for characterizing an optical transmission path in a network with network traffic, the method comprising:

modulating an optical signal with a pilot tone and outputting the modulated optical signal onto the optical transmission path;

sweeping the pilot tone across a frequency range;

detecting amplitudes and phases of the pilot tone along a forward path and a reflected path of the optical transmission path; and

characterizing the optical transmission path based on the detected amplitudes and phases.

2. The method as claimed in claim 1 wherein the characterizing includes determining at least one impairment in the optical transmission path.

3. The method as claimed in claim 2 wherein the optical transmission path is a fiber; and

the determining includes determining a disconnection, crimp, obstruction, defect, or assembly error.

4. The method as claimed in claim 1 wherein the characterizing includes determining dispersion in at least a portion of the optical transmission path.

5. The method as claimed in claim 4 further including automatically correcting the dispersion.

6. The method as claimed in claim 1 wherein the detecting is co-located.

7. The method as claimed in claim 1 wherein the detecting is non-co-located across a length of the optical transmission path having a known characteristic.

8. The method as claimed in claim 1 wherein the sweeping of the pilot tone maximizes the spatial resolution of the measurements.

9. The method as claimed in claim 8 wherein the sweeping ranges between about 0.5 MHZ and about 2.5 MHZ.

10. The method as claimed in claim 1 wherein the sweeping includes selecting modulation frequencies essentially absent coherent modulations on the optical signal.

11. The method as claimed in claim 1 wherein the detecting of the pilot tone includes filtering the detected optical signal with a bandwidth sufficiently narrow to reject noise while preserving the pilot tone in a manner supporting accuracy requirements.

12. The method as claimed in claim 1 wherein the bandwidth of less than about 1 Hz.

13. The method as claimed in claim 1 wherein the detecting of the pilot tone includes filtering the detected optical signal with an adaptable bandwidth to allow tradeoff of signal to noise and associated accuracy versus detection time.

14. The method as claimed in claim 1 wherein the characterizing is based on a relative measurement of amplitudes and phases.

15. The method as claimed in claim 1 wherein the optical transmission path is a fiber.

16. The method as claimed in claim 1 used in a wavelength division multiplexed or time division multiplexed system.

17. An apparatus for characterizing an optical transmission path in a network with network traffic, the apparatus comprising:

a modulator that modulates an optical signal with a pilot tone and outputs the optical signal onto the optical transmission path carrying network traffic;

a sweep controller coupled to the modulator that causes the modulator to sweep the pilot tone across a frequency range;

a detection unit coupled to the optical transmission path and that detects amplitudes and phases of the pilot tone along a forward path and a reflected path of the optical transmission path; and

a processing unit responsive to the detection unit that characterizes the optical transmission path based on the detected amplitudes and phases.

18. The apparatus as claimed in claim 17 wherein the processing unit determines at least one impairment in the optical transmission path.

19. The apparatus as claimed in claim 18 wherein the optical transmission path is a fiber; and

the at least one impairment includes a disconnection, crimp, obstruction, non-uniformity, defect, or assembly error.

20. The apparatus as claimed in claim 17 wherein the processing unit determines dispersion in at least a portion of the optical transmission path.

21. The apparatus as claimed in claim 20 wherein the processing unit automatically causes a dispersion correction in response to determining the dispersion.

22. The apparatus as claimed in claim 17 wherein the detection unit includes at least one optical detector that senses the pilot tone and provides a corresponding electrical signal.

23. The apparatus as claimed in claim 22 further including a dual coupler coupled to the optical transmission path and connected to each optical detector, wherein the dual coupler provides between about 2% and 5% of the optical signal to the at least one optical detector.

24. The apparatus as claimed in claim 22 further including at least one receiver coupled to each optical detector to convert the electrical signal to digital data.

25. The apparatus as claimed in claim 24 wherein the processing unit employs a frequency to time transformation to assist in characterizing the optical transmission path.

26. The apparatus as claimed in claim 24 wherein the processing unit executes a time-to-frequency transformation to assist in characterizing the optical transmission path.

27. The apparatus as claimed in claim 22 wherein two optical detectors are co-located.

28. The apparatus as claimed in claim 22 wherein two optical detectors are non-co-located and separated by a portion of the optical transmission path having a known characteristic.

29. The apparatus as claimed in claim 17 wherein the sweep controller causes the modulator to sweep the pilot tone to maximize the spatial resolution of the measurements.

30. The apparatus as claimed in claim 17 wherein the sweep controller causes the modulator to sweep between about 0.5 MHZ and 2.5 MHZ.

31. The apparatus as claimed in claim 17 wherein the sweep controller selects modulation frequencies essentially absent coherent modulations on the optical signal.

32. The apparatus as claimed in claim 17 wherein the detection unit includes a filter to filter the detected optical signal with a bandwidth sufficiently narrow to reject noise while preserving the pilot tone as needed by the accuracy requirements.

33. The apparatus as claimed in claim 32 wherein the processing unit filters the optical signal with a bandwidth of less than about 1 Hz to detect the pilot tone.

34. The apparatus as claimed in claim 17 wherein the detection unit includes a filter having an adaptable bandwidth to allow tradeoff of signal to noise and associated accuracy versus detection time.

35. The apparatus as claimed in claim 17 wherein the processing unit characterizes the optical transmission path based on a relative measurement of the amplitudes and phases.

36. The apparatus as claimed in claim 17 coupled for use in a wavelength division multiplexed or time division multiplexed system.

37. An apparatus for characterizing an optical transmission path in a network with network traffic, the apparatus comprising:

means for modulating an optical signal with a pilot tone and for outputting the optical signal onto the optical transmission path carrying network traffic;

means for sweeping the pilot tone across a frequency range;

means for detecting amplitudes and phases of the pilot tone along a forward path and a reflected path of the optical transmission path; and

means for characterizing the optical transmission path based on the detected amplitudes and phases.

38. A computer-readable medium having stored thereon sequences of instructions, the sequence of instructions, when executed by a digital processor, causing the process to perform the steps of:

modulating an optical signal with a pilot tone, the optical signal being output onto an optical transmission path in a network with network traffic;

sweeping the pilot tone across a frequency range;

obtaining detected pilot tone amplitude and phase along a forward path and a reflected path of the optical transmission path; and

characterizing the optical transmission path based on the detected pilot tone amplitudes and phases.

39. A data communications system for characterizing an optical transmission path in a network with network traffic, the system comprising:

optical I/O providing data transfer across the optical transmission path; and

a swept frequency reflectometry subsystem including (i) a modulator to apply modulation to an optical signal across a frequency range in a swept manner, (ii) a detector coupled to the optical transmission path to detect the

modulation along forward and reflected paths in the optical transmission path, and (iii) a processor coupled to the detector characterize the optical transmission path based on amplitudes and phases of the modulated optical signal in the forward and reflected paths.

40. The system as claimed in claim 39 wherein the processor determines at least one impairment in the optical transmission path.

41. The system as claimed in claim 39 wherein the processor determines dispersion in at least a portion of the optical transmission path.

42. The system as claimed in claim 41 wherein the processor causes a correction of the dispersion.

43. The system as claimed in claim 39 wherein the swept frequency reflectometry subsystem selects modulation frequencies essentially absent coherent modulations on the optical signal.

44. The system as claimed in claim 39 wherein the optical transmission path is a fiber.

45. The system as claimed in claim 39 wherein the optical I/O supports wavelength division multiplexing or time division multiplexing.